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A Job Aid: Incorporating Continuous Operations Considerations in Unit Design

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This document provides guidance to unit designers for the development of Army units with enhanced continuous operations (CONOPS) capability. It complies with key policy and guidance from the Office of the Secretary of Defense, Department of the Army, and USA TRADOC publications. It is organized to answer three questions: (1) why consider CONOPS during unit design; (2) how is CONOPS capability provided in unit design; and, (3) how are shortcomings in unit CONOPS capability identified? In addition, this job aid is designed to fill some of the gaps existing in current regulations and guidance concerning the incorporation of CONOPS into unit design. The material is applicable to TRADOC and other agencies responsible for designing and developing Army units.

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CONTENTS

A JOB AID: INCORPORATING CONTINUOUS OPERATIONS CONSIDERATIONS IN UNIT DESIGN

INTRODUCTION

Purpose

U.S. military forces must be capable of global deployability, rapid responsiveness, and extended combat operations. Since today's weapons are designed to be employed during adverse weather and around the clock, an important consideration is whether Army units are manned sufficiently to exploit the technological advantage offered by this 24-hour capability. By doctrine, U.S. Army units must have sufficient resources for continuous operations (HQ, Department of the Army, 1993).

To maintain 24-hour coverage for an extended period, technology-intense units such as air defense, field artillery, and maneuver battalions, their tactical operations centers (TOCs) (i.e., division-, brigade-, and battalion-level command and control centers), and their supporting elements require soldier-equipment ratios that permit down time (via crew rotations and work-rest scheduling) for rest, resupply, and maintenance while the battle continues.

Job aids are needed to assist the force designer in designing units for continuous operations. The manpower considerations of operating and maintaining the unit in realistic conflict environments require the inclusion of unit endurance parameters. Such planning falls within the purview of the manpower and personnel integration (MANPRINT) initiative. The goal of MANPRINT is to enhance soldier system performance by influencing soldier issues during weapon system design, development, production, and fielding. Given the constraints of decreasing resources, manning levels, and funding, the Army must ensure that new systems will meet performance requirements. The MANPRINT program provides a process for formal consideration of (1) the numbers of personnel required to operate and maintain a system, (2) the requisite skills, (3) training resources to help people achieve proficiency levels, (4) safety and hazards issues, (5) soldier survivability issues, (6) soldier costs, and (7) design trade-offs. The ability to maintain mission effectiveness for long periods of time should be a consideration during the unit design process.

Many variables impact unit military performance. As examples, crew training, task design, conditions of the battlefield, personnel characteristics all have an influence (see Figure 5-1 of Wagner [1995] for a complete listing). This job aid focuses on some of these variables to

enhance unit design for continuous operations. While these variables impact other design objectives (e.g., the ability to sustain casualties and to reconstitute), the focus of this paper is to enhance ability to perform continuous operations.

Definitions

Continuous operations (CONOPS), according to Joint Pub 1-02 (Joint Chiefs of Staff, 1994), is, in principle, the "degree or state of being continuous in the conduct of functions, tasks, or duties necessary to accomplish a military action or mission in carrying out the national military strategy." Addressing the more narrow view of unit design, CONOPS is combat continuing at the same high intensity level for extended periods. Soldiers may have opportunities for sleep, but sleep may be brief or fragmented.

From FM 22-9 (Soldier Support Center, 1991), "CONOPS is distinguished from SUSOPS (sustained operations). In SUSOPS, the same soldiers and small units engage in continuous operations with no opportunity for the unit to stand down and very little opportunity for soldiers to get more than a few minutes of sleep. Within any CONOPS, there are likely to be periods of SUSOPS."

WHY CONSIDER CONOPS DURING UNIT DESIGN

Advanced Warfare Concept

The following paragraphs, quoted from FM 22-9, summarize the problems that result from around-the-clock warfare:

> Continuous land combat is an advanced warfare concept. It is made possible by the almost complete mechanization of land combat forces and by the technology that permits effective movement at night, in poor weather, and in other low-visibility conditions. Continuous combat operations may be fast-paced, around-the-clock, and intense. The reasons that armies have traditionally paused in battle - darkness, resupply, regrouping - have been overcome largely by technological advancements. Now that armies have the potential to fight without let up [sic], night operations will become commonplace.
>
> This continuous cycle of day/night operations may cause degradation of performance in cognitive skills beginning as early as 18 to 24 hours into

CONOPS. The ability to think clearly deteriorates even more rapidly than strength and endurance. Mood, morale, initiative, and motivation decline along with mental performance.

The effects of CONOPS are sometimes hidden and difficult to detect. Units are obviously impaired when soldiers are killed or wounded in action or become noncombatant losses. They are further impaired when soldiers are too tired to perform their tasks.

Examples of CONOPS Organizational Deficiencies

This subsection offers the combat developer concrete examples of organizational design shortcomings. Three combat organizations (armor, aviation, and field artillery) were selected, and examples of both CONOPS and SUSOPS are presented to illustrate common unit design shortcomings. The shortcomings presented below are based on National Training Center and Operation Desert Shield-Storm after-action reports.

Armor

Assuming that tank crews in general can find time for 3 to 4 hours of sleep each day, the weakest links in a tank battalion's SUSOPS capability are the command and control structure, reconnaissance, and supporting logistics elements, not the line platoons (U.S. Army CACDA, 1987).

(1) The battalion reconnaissance platoon habitually receives more missions than resources and time allow (U.S. Army CACDA, 1987).

(2) Sleep deprivation is sometimes a problem in support platoons. If a low operator-to-equipment ration exists, resource constraints could lead to logistical problems, as for example, having sufficient truck drivers to provide around-the-clock support (U.S. Army CACDA, 1987).

(3) The battalion TOC is designed for two-shift operations. In theory, the seven personnel authorized (three officers, two NCOs, and two enlisted) should be able to coordinate battalion operations; in practice, however, difficulties often occur, particularly when a command group is formed, security is required, and frequent displacements occur. Consequently, TOC personnel become overstressed. Commanders, in response, call on personnel from tank platoons to augment the understaffed TOC (U.S. Army CACDA, 1987).

Army Aviation

Maneuver force commanders, as reported by the U.S. Army Aviation Center, Operation Desert-Storm after-action report, expressed concern about the lack of a robust aviation force structure during Operation Desert Storm. Deployed aviation units had a limited capability to operate 24 hours a day for an extended period during Operation Desert Storm. Organizational shortcomings included (U.S. Army Aviation Center, 1991)

(1) Lack of depth in critical aviation maintenance military occupational specialties (MOSs) hindered aviation operations. In addition to performing supervisory duties, crew chiefs also drove trucks, performed aircraft maintenance, and executed additional duties such as guard and waste disposal. Hence, they had little time for sleep and personal hygiene. Although these shortcomings have since been fixed, their existence demonstrates the sorts of problems that can occur when operations and support requirements exceed personnel resources.

(2) Inadequate aircrew-to-airframe ratio. The Army's allocation policy of one aircrew per helicopter limited helicopter availability. In fact, strenuous flying conditions such as night flying further reduced this availability. Aircraft availability was also reduced by aircrew illness and injury. In response to these conditions, aviation unit commanders tended to employ their aircraft as either day or night systems. The lack of back-up aircrews limited commanders in employing their aircraft for more than 8 hours per day. Longer employment required commanders to extend aircrew endurance schedules and to accept greater risks as a result of aircrew fatigue. Consequently, individual helicopters only flew an average of 32 hours during Operation Desert Storm's 100-hour ground campaign.

(3) Inadequate manning and equipment authorizations hindered continuous operations of forward area air refueling points (FARPs). FARP equipment includes rough terrain forklifts, fuel pumps, and tanker heavy expandable mobility tactical trucks (HEMTTs). Personnel authorizations at FARPs were too lean to sustain 24-hour operations. The manning shortage was partly attributed to the fact that FARP personnel had to drive trucks and perform other duties in addition to their arming and refueling responsibilities. Additionally, FARPs moved much like TOCs; one FARP had to be operational while the second moved to the new location. However, units had only enough personnel to man one FARP, and therefore, mission capability was missing during moves.

(4) Aviation unit TOCs lacked the mobility, automation, survivability, communications, and manning required to maintain operational tempo with their ground maneuver counterparts. The lean TOC manning was exacerbated by the fact that aviators, as TOC staff officers, were required to fly combat missions to meet operational needs.

Field Artillery (FA)

Operation Desert Shield-Storm experience demonstrated that the personnel redundancy and substitutability built into field artillery (FA) battery design ensured sufficient time for rest and sleep. Not unexpected, the weakest CONOPS links in the fire support system during sustained operations were the command and control structure and the supporting logistics elements, not the firing batteries (U.S. Army Field Artillery School, 1991).

(1) FA HEMTTs require two drivers to support continuous operations. The shortage of drivers adversely impacted the resupply of ammunition, fuel, and water.

(2) Fire support elements (FSEs) were inadequately staffed at brigade and battalion to support 24-hour operations. Consequently, FSE personnel were overworked to the point of exhaustion.

Human Performance Degradation

The shortcomings just described are not isolated examples; rather, they are typical CONOPS unit design deficiencies. Such deficiencies are likely to lead to performance degradation. The unit designer may wish to consider the following principles of performance during the design process:

- The soldier is the weak link in around-the-clock combat. In light of this fact, the unit designer may want to consider higher strength levels for selected mission-essential equipment.

- Positions involving high cognitive functioning such as reasoning, memory, and analysis are usually the first skills to deteriorate during sustained operations.

- A unit's weakest CONOPS links tend to be in functional areas in which mission performance depends upon a few soldiers who possess unique skills. These functional areas are command and control, communications, reconnaissance, and logistics.

One Key Variable

One reason that the soldier is considered the weakest link in CONOPS is that soldiers need sleep. Continuous combat is exhausting. The lack of sleep reduces a soldier's ability to perform tasks as quickly or effectively as necessary. When performing continuous operations, soldiers accumulate a sleep debt that degrades performance. The only preventive or corrective measure for sleep loss is sleep itself. Factors such as training and motivation can reduce the initial effects of sleep loss; however, no amount of training or motivation will sustain a soldier's performance. Unit designers must understand and consider the following tenets from FM 71-100-1 (Command and General Staff College, 1993):

- Six to eight hours of sleep are required for soldiers to maintain performance indefinitely.

- Four to five hours of sleep allow soldiers to maintain effective performance for 5 to 6 days.

- Performance degradation when working without sleep is estimated to be about 25% after 24 hours.

Other Relevant Variables

Other variables that impact human performance during CONOPS are the nature of the work task to be performed (physical versus cognitive), the degree of vigilance required to perform the work, the time of day the work will be performed, and environmental factors such as heat, cold, crowding, and vibration.

(1) Physical Versus Cognitive Tasks. Certain tasks are more susceptible to the effects of sleep loss than others. Thinking ability degrades more rapidly than physical strength as shown by Figure 1 (U.S. Army CAC, November 1993).

The susceptibility of tasks to performance degradation is as follows:

- The tasks most susceptible to performance degradation are those requiring creative and original thought.

- The next most susceptible are tasks requiring logical reasoning or sound judgment.

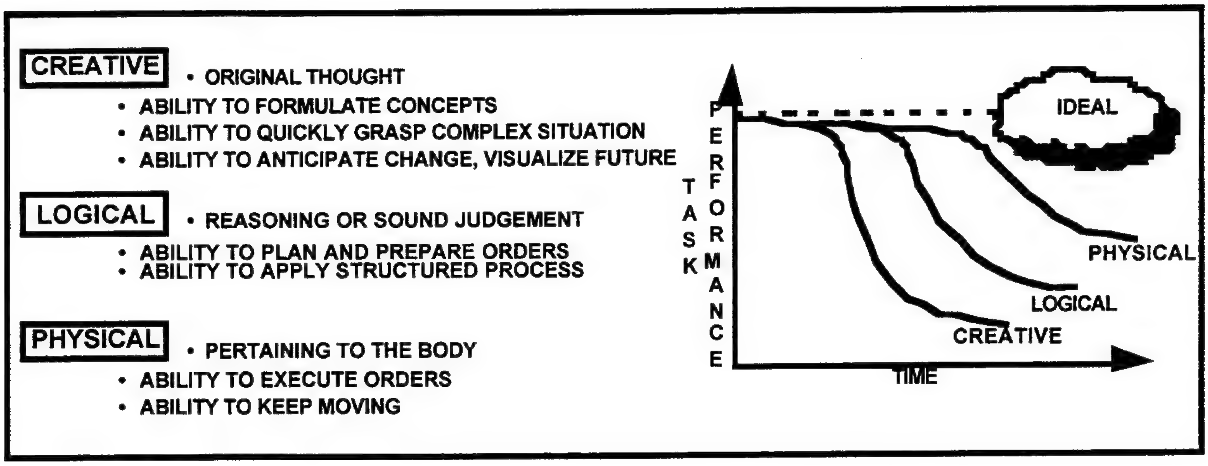

Figure 1. Task degradation.

• The least susceptible are tasks requiring physical performance such as the ability to follow orders and the ability to keep moving. Sustained physical effort, however, will lead to muscle fatigue and eventual failure to function.

(2) Vigilance Tasks. Vigilance tasks are those that require constant and concentrated attention during conditions that are seldom conducive to alertness or attention. Vigilance operations are characteristic of defensive operations, notably sentry duty and monitoring air defense and ground surveillance radars. Performance degradation manifests itself as missed detection opportunities. The operational consequence of a missed detection is task and situation dependent. The consequences, however, could be significant, for example, if the missed detection resulted in defenses not being prepared for an enemy attack. Typically, vigilance tasks are performed only during a portion of a normal duty cycle. For high vigilance tasks, cognitive performance can deteriorate after 20 to 25 minutes of continuous work (Krueger, 1989). Vigilance task performance degradation with fatigue is well recognized and unit commanders know that they cannot rely on long duration vigilance performance.

(3) Time of Day (rhythmic variations in performance). The following paragraphs from FM 22-9 nicely summarize the relevance of this variable on human performance:

> There are rhythmic variations in individual performance based on a predictable physiological and behavioral cycle that is about one day or 24 hours. The 24-hour, day-night/work-rest cycle is called the "circadian rhythm."

> Although one's "normal" temperature is 98.6 degrees, this is really an average or midpoint of a daily swing from 96.8 to 100.8 degrees.... There is a well-established link between body temperature and sleepiness and/or performance slumps. Performance parallels body temperature. The higher the temperature, the better is the performance. As temperature decreases, there is a decline in mood and motivation and an increase in sleepiness and fatigue.

For someone accustomed to working days and sleeping nights, the performance impact is most pronounced during the circadian lull which is roughly 0200 to 0600 hours. Performance can decline 10% to 15%; however, in sleep-deprived soldiers, this decline can become 35% to 40%.

(4) Environmental Factors. CONOPS frequently take place in environments that contribute additional stress and subsequent performance degradation. Ambient temperatures in excess of 85° Fahrenheit (wet bulb globe) may cause reduced performance (both physical and cognitive) from excessive sweating (which can cause slippage or degraded vision), dehydration, and hypothermia. Prolonged exposure to cold may degrade manual dexterity because of shivering and synovial swelling and can lead to exhaustion, dehydration, and hypothermia. Ambient noise and vibration may cause difficulty in reading displays and can reduce cognitive performance and cause nausea and vomiting.

The next section examines strategies to reduce CONOPS risks with focus on the organizational design perspective.

WAYS FOR INCORPORATING CONOPS IN UNIT DESIGN

CONOPS Risk Reduction Strategies

The many factors have been summarized, which can impact the ability of soldiers to perform tasks effectively for long periods of time. Methods for reducing CONOPS risks can be grouped into four broad strategies. These strategies, with associated planning lead time and responsibility, are displayed in Table 1 and summarized afterward.

Table 1

CONOPS Risk Reduction Strategies

Strategy	Planning lead time	Responsibility
Doctrine and leadership	Hours, days	Commander
Training	Weeks, months	Commander
Materiel	10 to 20 years	Combat developer
Organizational	10 to 20 years	Combat developer

Doctrine and Leadership

This category comprises doctrinal actions and leadership techniques which are designed to ameliorate the adverse effects of CONOPS on personnel performance. In general, these actions are implemented by a unit commander before and during the course of CONOPS. The commander anticipates, plans, and rehearses the battle in conjunction with mission, enemy, terrain and weather, troops available-time (METT-T) and FM 22-9 to ensure time for rest and sleep. In conjunction with a METT-T determination for future courses of action, and as unit capabilities permit, the commander designates elements of his unit to be inactive for rest and maintenance.

Training

The commander institutes unit training initiatives to reduce the effects of CONOPS on personnel through cross-training and overlearning mission-essential skills. Cross-training allows duties to be shared and permits scheduled rest periods. Overlearning assures higher reliability and rapid skill performance.

Materiel

In the 21st century, the technical capabilities of the soldiers and systems that the Army fields will represent the interplay of two distinct and interrelated processes. One is "technology push," the process of scientific research and technological innovation that determines what is available. The other is "requirements pull," a process that includes a wide

array of factors that affect Army needs and requirements, and these are driven by the mission, the threat, and political and economic changes at home and abroad.

The role of the combat developer in the requirements pull process is to define the equipment needed to support future doctrine. With the knowledge that human performance is the limiting factor in CONOPS, the combat developer must consider materiel alternatives to redress this limiting factor. More consideration should be given to the concept of optimal allocation of tasks between the system and the operator.

Organizational

Manpower and equipment authorizations and organizational structure, together with an operational concept are the principal determinants of how a unit will perform during CONOPS. A unit commander's tactical and training CONOPS strategies are viable only to the extent that this unit has been designed with sufficient resources for CONOPS. This organizational concept is developed fully in the remainder of this section.

The Organizational Design Perspective

Personnel and equipment authorizations and organizational structure, in combination with an operational concept define a unit's CONOPS mission capability. From a CONOPS organizational design perspective, the desired characteristics of a unit are

Sufficiency

Each unit possesses sufficient personnel and equipment to perform its mission-essential tasks for continuous operations. Sufficient personnel means that enough soldiers are assigned to each combat task to assure all soldiers an opportunity for 6 to 8 hours sleep every 24-hour cycle.

Sustainability

Each unit possesses sufficient support personnel and equipment to sustain mission-essential tasks during CONOPS. This means that maneuver units have not only enough soldiers to fight the battle but also enough truck drivers, maintainers, radio operators, and so forth, to sustain the battle.

Robustness

Each unit possesses sufficient internal redundancy to absorb losses and still accomplish its mission. Internal redundancy is the existence of multiple elements that allow designated elements to replace one another for sleep rotation while the unit continues to perform all mission-essential tasks.

Normally, resources, particularly personnel, are constrained in the design of a unit, either in quantity (numbers of soldiers) or quality (skill levels and experience). To the unit designer, working under personnel "ceilings," and looking for "bill payers" are facts of life. This means that if the unit designer wants to augment an organizational element with additional personnel, for example, to provide a multi-shift capability, the space authorizations must come from somewhere else; that is, a bill payer must be found. Finding a bill payer has always been difficult but with the force reduction, it will become even more so in the future. Therefore, the unit designer should not only consider unit strength alternatives but also unit design alternatives, including new and innovative operational concepts.

CONOPS Decision Tree

CONOPS unit design alternatives are displayed graphically in Figure 2 using a decision tree format. The tree displays CONOPS organizational alternatives, as a function of unit type, using TRADOC Pamphlet 11-9 (ARL, 1993), tactical taxonomy for categorizing military units and functions.

Combat Battlefield Functions

The tree's upper branch contains three combat battlefield functions: maneuver, fire support, and air defense. Army policy (AR 71-31) states that units whose primary mission is to engage and inflict casualties (Category I units) must have sufficient resources by doctrine to allow continuous operations. This means that staffing requirements will be developed based on a METT-T determination for future scenarios and CONOPS principles. Guidance about this staffing process is provided in Wagner (1995), which provides a discussion of unit design principles and procedures, including the consideration given to CONOPS.

The upper branch displays two unit design methods for ensuring a CONOPS mission capability: (1) individual substitutability, and (2) system substitutability. The individual substitutability method ensures sufficient resources so that individual soldiers or crew members

can be inactive for sleep through crew rotation. The system substitutability method ensures sufficient robustness so that designated elements of the unit can be inactive for specified periods of time so that entire crews can sleep.

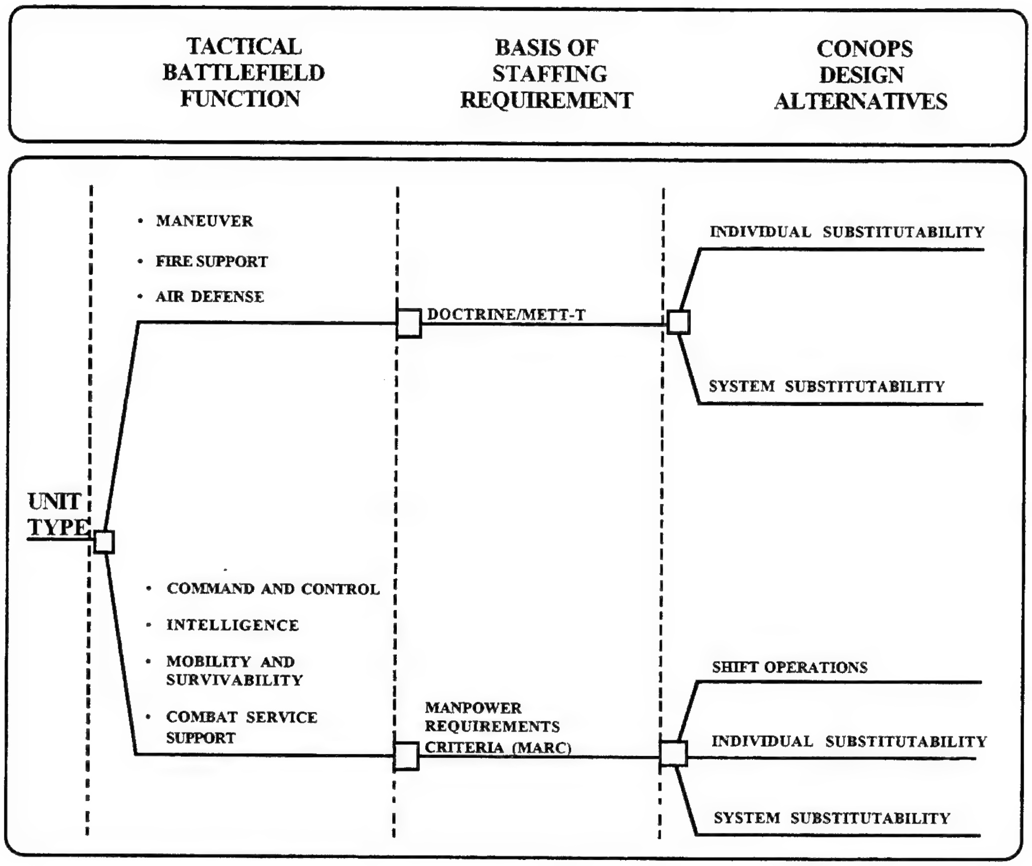

Figure 2. CONOPS unit design organizational alternatives.

Combat Support and Service Support Functions

The tree's lower branch shows CONOPS design choices for the remaining tactical battlefield functions: command and control, intelligence, mobility and survivability, and combat service support. For these battlefield functions, staffing requirements are governed by AR 570-2 (HQ, Department of the Army, May 1992), which prescribes Army policies and procedures for combat support and combat service support units and elements. Manpower requirements criteria (MARC) staffing requirements are based on historical experience or field measurement of the number of hours required to perform a task or function. In the absence of empirical data, the unit designer can make assumptions and propose a staffing basis until actual experience is gained. MARC methodology is based on the concept of providing minimum essential manpower to

perform wartime functions during an average day of military operations. An average day varies by type unit and employment echelon (i.e., division, corps, and echelons above corps). In an average day, 10 to 12 hours are available for productive MOS work, and the remaining time is required for eating, sleeping, performing details, unit relocation, and so forth. Consistent with the CONOPS sleep guideline, MARC allots 7 hours per day for sleeping. MARC, however, does not allocate personnel resources for SUSOPS and a mission surge capability per se.

The tree's lower branch shows that shift operations is a third CONOPS design alternative with application to combat support and service support functions such as intelligence, command and control, and so forth. Shift operations are appropriate for tasks that must be performed around the clock for an extended period of time. The design can provide for two shifts with equal capability operating around the clock. Alternatively, it can provide for full capability during selected periods of time and reduced capability during other periods.

CONOPS Unit Design Alternatives

CONOPS capability often has been considered erroneously in terms of individual soldiers functioning 24 hours per day rather than from an organizational perspective. To the unit designer, CONOPS-capable means that a unit, consisting of personnel, equipment, and an operational concept, can perform its mission 24 hours per day for a sustained period of time.

The three CONOPS design alternatives depicted in Figure 2 and discussed briefly are discussed in more detail with examples in subsequent paragraphs.

Design for Sufficient Individual Substitutability

This design alternative is the most basic and commonly used procedure for ensuring unit CONOPS capability. It is universally applicable, regardless of battlefield function, unit type or employment zone. The essence of this approach is to ensure sufficient personnel to permit sleep rotation for mission-essential tasks. Whether the task involves logistics, command and control, or manning a weapon system, the commander needs the ability to cross-train individuals and establish sleep rotation schedules. To be viable, this approach requires not only sufficient personnel resources but also an implementing procedure.

The M109 (A2 through A5) series self-propelled 155-mm howitzer and the AN/PPS-5A ground surveillance radar are two specific examples of individual substitutability designs. Each is discussed in turn.

(1) Howitzer Crew. The CONOPS mission of a field artillery (FA) battalion is to support maneuver forces with continuous and overlapping fires on the battlefield around the clock. An FA battalion is comprised of three FA batteries. Each battery consists of two platoons, and each platoon has four howitzer sections.

A self-propelled howitzer section has a nine-man crew (see Table 2). As stated in TM 9-2350-311-10 (HQ, Department of the Army, Apr 1992), it is normal to expect gun crews to be reduced to less than the prescribed strength because of illness, casualties and the need for rest. To meet the needs of these occasions, reduced crew and cross-training procedures have been developed together with a sleep rotation plan.

Table 2

Self-Propelled Howitzer Crew Composition

Full crew	Reduced crew		
9-man	8-man	7-man	6-man
Chief of section (CS)	CS	CS	CS
Gunner (G)	G	G	G
Ammunition team chief (ATC)	ATC	ATC	ATC
Assistant gunner (AG)	AG	AG	AG/HD
Cannoneer No. 1	No. 1	No. 1	No. 1
Cannoneer No. 2	No. 2	No. 2/No. 3/AVD	No. 2/No. 3/AVD
Cannoneer No. 3	No. 3/AVD	-	-
Ammunition vehicle driver (AVD)	-	-	-
Howitzer driver (HD)	HD	HD	-

Table 2 shows that firing missions can be performed with a reduced crew of eight, seven, or six crewmen by combining the duties of individuals as shown. By stipulating that all crew members will have the same MOS, additional CONOPS flexibility is achieved through cross-training. For example, the Ammunition Team Chief (ATC) can be trained for gunner and Chief of Section (CS) duties, and the numbered cannoneers can be expected to know the duties of all the other cannoneers, and so forth.

The operator's manual for this howitzer further reads

> The section must be drilled until reaction to commands is quick, automatic and correct. Battery officers will supervise the drill. Duties should be rotated during training so that each member of the section can perform all duties within the section.

Any combination of six crew members can perform firing missions and this flexibility permits the development of sleep rotation plans that allow members to obtain as many as 6 hours of sleep every 24 hours.

(2) Radar Crew. The CONOPS mission of the AN/PPS-5 radar team is to support a maneuver brigade with mobile, real-time, 24-hour battlefield ground surveillance. Radar teams may be deployed singly or in conjunction with other ground surveillance assets. Operators interpret some types of target information and provide other data directly to indirect fire systems for immediate attack. The radar is usually employed for continuous operations. The radar is set to ready only when enemy activity is not evident.

The radar has two scopes (monitors) with a viewing hood and a headphone. Watching the two scopes through a viewing hood while listening to the headphone requires intense concentration and is very fatiguing work. Cognitive performance of this high vigilance task deteriorates rapidly after 1 hour. To maintain minimum essential task performance, the radar operator position must be rotated among team members. While two people can operate this radar for a limited period of time, the work load driver is the number of operator positions needed for this system on a sustained basis. Four radar operators, MOS 96RXX, are needed to perform minimum essential radar operator tasks while rotating the high vigilance radar monitoring task among crew members and maintaining a sleep rotation plan. Without the high vigilance requirement, the radar tasks could be performed by a three-man crew (U.S. Army CAC, August 1993).

A technique that uses the individual substitutability concept to identify CONOPS shortcomings in a unit design is discussed in the section "An Approach for Identifying CONOPS Shortcomings in a Unit Design."

Design for Sufficient System Substitutability

This design alternative is applicable to all battlefield functions, particularly if

organized hierarchically. Typically, Army combat units are organized hierarchically. The basic building block is the individual weapon system. For field artillery, the hierarchy is composed of sections, platoons, batteries, battalions, and division artillery-groups-brigades. The essence of this CONOPS design is to ensure sufficient overlapping mission capability so that crews or elements can be inactive for specific periods of time. Force structure robustness is a necessary, not a sufficient, condition. A CONOPS implementing procedure is also needed. How system substitutability can ensure CONOPS mission capability is illustrated by the following example.

The field artillery views the CONOPS requirement as the ability to deliver sufficient overlapping fires on the battlefield around the clock to support maneuver forces. When mission capability exists that exceeds the requirement for overlapping fires, designated elements can be permitted to be inactive for rest and maintenance. For the purpose of resting a section or platoon, a battery commander can decrease the readiness of designated firing elements from a normal fully ready or "hot" status, to a "warm" or a "cold" status. The CONOPS applications are best described as follows:

- Warm platoon. During intense continuous operations, a platoon can be inactive while maintaining firing capability. The platoon is required to monitor radios, but no fire missions are sent unless absolutely necessary.

- Cold platoon. This option takes an entire platoon out of action for a period as long as 6 hours. The primary purpose of this option is to enable the command and control elements of the platoon to concentrate on the sustainment and resting of the platoon. This would include at least 4 hours of uninterrupted sleep.

- Cold section. This option takes an entire section out of action for a designated period of time. The section may even be moved to an assembly area away from its platoon. If the cold section remains with the platoon or is in an assembly area with other battalion elements, it may not be required to maintain a radio watch, as this may interrupt sleep.

Design for Shift Operations

This design alternative applies to tasks that must be performed continuously, around the clock, 7 days a week, for an indefinite period of time. Typically, the tasks involve a projected constant work load overtime and involve high cognitive or vigilance work. Army command posts (CPs) at brigade, division, and corps are examples of entities designed and

organized for shift operations. The organizational design of CPs provides important insights about shift work and design challenges for the future.

A typical CP, particularly at division and corps, is considered too large and too vulnerable to enemy acquisition and attack. TRADOC has several on-going programs at the Battle Command Battle Laboratory (i.e., Battle Staff Assessment and Battle Command Concept Projects) focused on reducing CP size while maintaining a 24-hour capability. Basically, two ways provide opportunities to reduce CP staff size by (1) consolidating elements of a CP, and (2) automating selected tasks that staff members now perform manually.

Typically, any large maneuver organization (division and corps) establishes three CP echelons in support of its basic mission functions:

- A tactical CP to manage the current battle.
- A main CP to provide overall control of the battle and to plan the next battle.
- A rear CP to manage logistics activities and sustain the battle.

Subdividing division and corps CPs into elements serves to increase survivability through dispersion but at a price of additional personnel requirements. Currently, the TRADOC Battle Command Battle Laboratory is assessing the feasibility of consolidating the rear and main CPs into a single element. This consolidated echelon would be employed out of harm's way in a rear area location, possibly in the continental United States (CONUS). This opportunity is made possible by the ability to establish a distributed interactive CP using digitized battlefield data supported by long range, high volume communications networks.

Key to effective CP operations is the quantity and quality of its staff. CPs are designed to be manned with the appropriate MOSs and skills to perform battlefield functions as functional cells. A corps main CP is comprised of six functional cells, while a division main CP has three cells (Command, G-3 [Operations], and G-2 [Intelligence]). For the purpose of 24-hour operations, each cell is staffed with sufficient individual substitutability for two shift operations.

Modern warfare, as evidenced by Operation Desert Storm, is fast paced, intense, and around the clock. The battlefield situation can change quickly. For CP operations, the time when efficient around-the-clock operations are most vulnerable is during personnel changes between shifts. Typically, CP work schedules evolve around two 12-hour shifts, dependent upon the availability of staff and the work performed. Work schedules can be arranged for shifts

with equal capability operating around the clock. Alternatively, the schedule can be arranged, contingent on the tempo and tenor of combat activity, for full capability during selected periods of time and reduced capability during other periods.

The procedure of changing the entire CP staff is counter to effective CONOPS. It results in the mass departure of the incumbent shift and the immediate loss of the collective knowledge of what occurred during the previous 12 hours. While the incoming shift will have been briefed and have access to logs, it will be confronted with situations for which no shift members have direct knowledge or understanding of the contextual circumstances. Provided there is sufficient individual substitutability for two shift operations, mitigating the effects of shift change and ensuring CONOPS can occur in one of two ways. The first way involves establishing several staggered overlapping shifts within each cell, and the second way involves employing shorter than 12-hour work cycles for designated tasks.

The staggered shift change provides for scheduling officers, NCOs, and enlisted personnel on three overlapping shifts so that the new shift has access to a body of knowledge that is only 4 to 6 hours old. For example, the officer 12-hour shift might run from 0800 to 2000 hours, the noncommissioned officer (NCO) shift from 1200 to 2400 hours, and the enlisted shift from 1600 to 0400 hours. This approach tends to reduce the knowledge gap problem. The entire staff can implement the staggered shift change either by each element or by cell, depending upon requirements and peak load times. By staggering shifts, the unit has a constant interface between new and old staff members within the CP.

While the 12-hour shift cycle is the most common, it is also the most difficult to sustain. If work loads are high, then fatigue degrades performance of this schedule. This is particularly true for the night shift that spans the circadian lull (0200 to 0600). Also, the 12-hour shift is particularly difficult to sustain if vigilance or creative work is involved. Alternatives to 12-hour shifts are the 4-hour on-off and 6-hour on-off work schedule. While the rest periods are short, they provide the opportunity for distributed rest. Although sleep might not be taken during each off period, the change in activity has a recuperative effect for tasks involving high cognitive and vigilance work. In general, the 8-hour on-off work schedule or any schedule in which sleep is not taken during the same time for successive 24-hour periods should be avoided. Sleep taken at different times of day or night is less valuable for maintaining optimal performance for CONOPS (Soldier Support Center, 1991).

The need for consistent sleep periods has additional negative implications for CONOPS because of the lack of adjustment time in most military settings. It takes an average of 21 days to adapt to a new sleep cycle, and changing sleep periods may have more of a detrimental effect on performance than the sleep time itself. This means that, whatever work and sleep cycles are adapted, they should be maintained with minimal changing. Also, adaptation to the CONOPS work and sleep schedule should be started as soon as possible.

In summary, the optimal CP design would consider the specific type of work required within each cell and element and ensure sufficient individual substitutability and CONOPS capability through a combination of staggered overlapping shifts and schedules of varying time intervals for high cognitive and vigilance work.

AN APPROACH FOR IDENTIFYING CONOPS SHORTCOMINGS IN A UNIT DESIGN

General

As discussed previously, a factor that impacts CONOPS capability is the ability of a unit commander to cross-train and cross-assign personnel to other positions within the unit to permit scheduled rest periods. Cross assignment is also important when a unit is short of personnel (understrength, leaves, casualties, etc.). A technique for checking the design of a unit for its ability to cross assign is for the unit designer to analyze the possible substitutability within the unit through the eyes of the commander. In units where a large degree of substitutability is possible, greater potential exists through doctrinal actions and leadership techniques to develop sleep rotation schedules to support CONOPS. When substitutability does not exist to any substantial degree, the unit may be susceptible to performance degradation in that respective task area during CONOPS.

Substitutability Matrix

A unit's CONOPS capability, as measured by a commander's ability to cross-assign personnel, can be assessed by means of a substitutability matrix. An example of a substitutability matrix is displayed in Table 3. The matrix is of an FA battery, field artillery battalion, 155-mm self-propelled, table of organization and equipment (TOE) 06367L200. The TOE job descriptions are listed in Rows 1 through 26 on the left-hand side of the table. The same personnel skills form Columns 1 through 26 across the table. For example, the platoon leader is cited in Row 7 and Column 7. The dash in each space of the diagonal from the upper

left to the lower right indicates that individuals in that row and column would not substitute for himself or herself.

Table 3

Substitutability Matrix: Field Artillery Battery

UNIT DESCRIPTION					SUBSTITUTABILITY ASSESSMENT																										
SECTION	POSITION	GR.	MOS	STR.	NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
(1) BATTERY HQ	CDR	CPT	13E001	1	1	-	X					X				X															
	1st SGT	E8	13Z5M	1	2	X	-					X	X	X																	
	SPLY SGT	E6	92Y30	1	3			-		X																					
	NBC NCO	E5	54B20	1	4				-																						
	ARMORER	E4	92Y10	1	5			X		-																					
	VEH DVR	E3	13B10	2	6						-				X							X	X	X	X	X	X	X		X	X
(2) FIRING PLATOON HQ	PLT LDR	LT	13E00	2	7	X	X					-	X	X																	
	PLT SGT	E7	13B40	2	8		X						-	X							X	X	X						X		
	GUN SGT	E7	13B40	2	9	X	X					X	X	-							X	X	X						X		
	VEH DVR	E3	13B10	2	10						X				-							X	X	X	X	X	X	X		X	X
(2) FIRE DIRECTION CENTERS	FD OFF	LT	13B00	2	11	X	X						X	X		-	X	X													
	CH FD CTR	E6	13E30	2	12								X	X		X	-	X	X		X	X	X	X	X	X	X		X	X	
	SR FD SPEC	E5	13E20	2	13						X		X	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X
	FD SPEC	E4	13E10	6	14						X				X		X	X	-	X	X	X	X	X	X	X	X	X	X	X	X
	FD SPEC	E3	13E10	4	15						X				X			X	X	-	X	X	X	X	X	X	X	X		X	X
(8) HOWITZER SECTIONS	SECT CH	E6	13B30	8	16		X						X	X							-	X	X	X	X	X	X		X	X	
	GUNNER	E5	13B20	8	17						X		X	X	X						X	-	X	X	X	X	X	X	X	X	X
	AMMO TM CH	E5	13B20	8	18						X		X	X	X						X	X	-	X	X	X	X	X	X	X	X
	ASST GNR	E4	13B10	8	19						X				X						X	X	X	-	X	X	X	X	X	X	X
	CANNONEER	E4	13B10	8	20						X				X						X	X	X	X	-	X	X	X	X	X	X
	AMMO VEH DVR	E4	13B10	8	21						X				X						X	X	X	X	X	-	X	X	X	X	X
	HOWITZER DVR	E4	13B10	8	22						X				X						X	X	X	X	X	X	-	X	X	X	X
	CANNONEER	E3	13B10	16	23						X				X							X	X	X	X	X	X	-		X	X
(1) AMMO SECTION	SECT CH	E6	13B30	1	24		X						X	X							X	X	X	X	X	X	X	X	-	X	
	AMMO SPEC	E4	13B10	3	25						X				X						X	X	X	X	X	X	X	X	X	-	X
	AMMO HDLR	E3	13B10	4	26						X				X							X	X	X	X	X	X	X		X	-

For the personnel skill in each row, a determination is made, based on field manuals, MOS guides, operational concepts, and other source materials, whether that person could substitute for the personnel skills listed in the columns of the table. For example, the table shows that the battery commander could substitute for the first sergeant, the platoon leaders, or the fire direction officer. Looking across each row of the table, the number of personnel for whom each individual can substitute can be identified. As an example, the section chief (Line 16) can substitute for 11 other individuals. Looking down each column, a determination can be made as to how many individuals can substitute for each skill. For example, 10 individuals can substitute for the platoon sergeant (Column 8).

Certain rules are necessary to develop a matrix. Two general rules were used in developing the matrix in Table 3. First, it was deemed necessary that the individual not only could substitute but would substitute. As an example, the battery commander could probably substitute for most other individuals in the battery, but he generally would not. Second, it was assumed that personnel could and would substitute, when necessary, for individuals with the same MOS two grades higher and two grades lower.

These rules are not unalterable and can be changed to accommodate different situations. For example, the impact of permitting substitutions only one grade higher and lower could be examined, or an assumption could be made that the commander would conduct selected cross-training and the impact on substitutability could be analyzed. Note that this process is not exact. Each unit designer may make different decisions with regard to an individual's ability to substitute for another individual. However, the exercise will provide indications as to where additional action is required by the unit designer or by the commander.

Analyzing a Unit's Individual Substitutability Capability

Once the matrix is developed, how is it analyzed? The first item of interest is to gain a general impression of the degree to which substitutability is possible within a unit. Analysis of the results displayed in Table 3 indicates that relatively good substitutability exists in a field artillery battery where there are large numbers of 13B artillerymen. The results can be expected to be similar in other units where large numbers of related MOSs occur, such as in infantry, mechanized infantry, and armor companies. In other units such as headquarters detachments, signal teams, and combat service support elements, less substitutability can be expected because, generally, more unique MOSs in fewer quantities are assigned to these latter units.

A second factor for interest is the identification of individual personnel skills for which no substitutability or very limited substitutability is possible. This can be determined by reading each column to identify columns in which no Xs or a limited number of Xs exist. In the field artillery battery example, no one can substitute for the nuclear-biological-chemical (NBC) NCO, and the supply sergeant and armorer can only substitute for each other. If it is believed that these positions must be manned continuously during CONOPS, the unit designer would be required to incorporate more personnel with similar skills, consider augmentation or cross-training, or ensure that external support is available for extended operations.

A third factor for analysis is the identification of unique cells of personnel. One situation is when the individuals within the cell can substitute internally but cannot substitute externally, nor can external elements substitute for individuals within the cell. A maintenance section might be an example of such a cell. A second case is when the individuals of the cell can substitute internally as well as externally, but external elements cannot substitute for individuals within the cell, as is exemplified by two fire direction sections. The fire direction section personnel can substitute for others within the battery, but the highly technical nature of the fire direction function prevents others within the battery from substituting for fire direction personnel. Thus, duties within each fire direction center must be defined so as to support continuous operations, or, perhaps operating procedures could be developed so that the two fire direction centers could be mutually supporting during CONOPS.

Cases when individual substitutability is limited and when unique cells exist are more prevalent in headquarters units and combat service support units where multiple, diverse MOSs exist, many times in only limited numbers.

This CONOPS test is universally applicable to all types of units, including CPs. Analyzing a CP organization with the aid of a substitutability matrix could identify opportunities for improving effectiveness or reducing staff requirements, while maintaining a 24-hour capability. This CP analysis is presented as an exercise for the interested reader. FM 71-100-1 (Command and General Staff College, 1993) provides the necessary details about the composition of CP elements and cells to perform the individual substitutability analysis.

SUMMARY

Designing a unit that is CONOPS capable is more an art than a science. Personnel and equipment authorizations and organizational structure, in combination with an operational concept define a unit's CONOPS mission capability. From a CONOPS organizational design perspective, the desired characteristics of a unit are

• Sufficiency. Each unit should possess sufficient personnel and equipment to perform its mission-essential tasks for continuous operations. Sufficient personnel means that enough soldiers are assigned to each combat task to assure all soldiers an opportunity for 6 to 8 hours sleep every 24-hour cycle.

• Sustainability. Each unit should possess sufficient support personnel and equipment to sustain mission-essential tasks during CONOPS. This means that maneuver units have not only enough soldiers to fight the battle but also enough truck drivers, maintainers, radio operators, and so forth, to sustain the battle.

• Robustness. Each unit should possess sufficient internal redundancy to absorb losses and still accomplish its mission. Internal redundancy is the existence of multiple elements that allow designated elements to replace one another while the unit continues to perform all mission-essential tasks.

The unit designer should consider the following principles of performance derived from Operation Desert Shield-Storm and National Training Center experience:

• Because soldiers need to rest, the unit designer may want to consider higher strength levels for selected mission essential equipment.

• Positions involving high cognitive functioning such as reasoning, memory, and analysis are usually the first skills to deteriorate during CONOPS sustained operations.

• A unit's weakest CONOPS links tend to be in functional areas in which mission performance depends upon a few soldiers who possess unique skills. These functional areas are command and control, communications, reconnaissance and logistics.

Unit commanders can cross-train personnel and provide for sleep rotation during CONOPS only to the extent that the unit designer has designed the unit with sufficient resources. With this objective in mind, this report describes three CONOPS design alternatives and a procedure for testing individual substitutability or robustness of a unit design.

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APPENDIX A

ABBREVIATIONS

ABBREVIATIONS

ATC	Ammunition Team Chief
AG	assistant gunner
CDR	Commander
CONOPS	continuous operations
CP	command post
CONUS	continental United States
CS	Chief of Section
FA	field artillery
FARP	forward arming refueling point
FSE	fire support element
FM	field manual
G	gunner
HD	howitzer driver
HEMTT	heavy expandable mobility tactical truck
HQ	Headquarters
MANPRINT	manpower and personnel integration
MARC	manpower requirements criteria
METT-T	mission, enemy, terrain, troops, and time available
MOS	military occupational specialty
NBC	nuclear, biological, and chemical
NCO	noncommissioned officer
SGT	Sergeant
SUSOPS	sustained operations
TM	technical manual
TOC	tactical operations center
TO&E	table of organization and equipment
TRADOC	Training and Doctrine Command

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